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ORIGINAL ARTICLE

Estimation of Stature from Foot Dimensions and Stature among South Indian Medical Students Using Regression Models

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Abstract:

Background: At times fragments of soft tissues are found disposed off in the open, in ditches at the crime scene and the same are brought to forensic experts for the purpose of identification and such type of cases pose a real challenge. *Objectives:* This study was aimed at developing a methodology which could help in personal identification by studying the relation between foot dimensions and stature among south subjects using regression models. *Material and Methods:* Stature and foot length of 100 subjects (age range 18-22 years) were measured. Linear regression equations for stature estimation were calculated. *Result:* The correlation coefficients between stature and foot lengths were found to be positive and statistically significant. Height = 98.159 + 3.746 × FLRT (r = 0.821) and Height = 91.242 + 3.284 × FLRT (r = 0.837) are the regression formulas from foot lengths for males and females respectively. *Conclusion:* The regression equation derived in the study can be used reliably for estimation of stature in a diverse population group thus would be of immense value in the field of personal identification especially from mutilated bodies or fragmentary remains.

Keywords: Foot dimensions, Identification, Stature, Mass Disaster.

Introduction:

Identification of an individual is the mainstay of forensic investigations. Estimation of stature forms a basic domain of the investigation process in unknown and co-mingled human remains in mass casualties and natural disasters. In situations like mass destruction even experienced forensic experts feel difficulties in the identification of bodies.

The mutilation of dead body can be done by criminals who wants to destroy all traces of identity and thus facilitate the disposal of the dead, scavenging animals and rarely by forces of nature rocks and fast flowing water. Forensic podiatry is the application of sound and researched podiatric knowledge and experience in forensic investigations, to show the association of a perpetrator with a scene of crime, or to answer any other legal question concerned with the foot that requires knowledge of the functioning foot [1, 2].

For estimation of stature, a lot of literature is available on long bones. However, only a few studies have reported estimation of stature from mutilated bodies or fragmentary remains. Therefore, this study was aimed at developing a relation between foot dimensions and stature

among south Indian subjects using regression models. In this study correlation between stature and foot dimension is estimated that will be helpful in estimating stature from mutilated or fragmentary remains of feet.

Material and Methods:

The present cross sectional study was carried out in the Department of Forensic Medicine during April 2011 to June 2011 at Institute of Medical Sciences, Puducherry. The study subjects comprised of 100 (65 males and 35 females) studying in 2nd year MBBS students between the age of 18 to 22 years since the maximum height of an individual is attained by this age. Cases having any significant disease, orthopaedic deformity, metabolic or developmental disorders which could have affected the general or bony growth were not included in this study and hence formed the exclusion criteria. Students were explained about the purpose of study and written informed consent was taken prior to commencement of the study.

All the measurements were recorded to the nearest centimeter using standardized anthropometric measuring equipment; stadiometer and sliding calipers which formed the study tools. The subject was made to stand barefoot in the standard standing position on the baseboard of standiometer. Both feet were in close contact with each other and head oriented in Frankfurt's plane. The height was then recorded in centimeter from the standing surface to the vertex in the weight bearing position of foot. Foot length was measured with the help of sliding calipers, taken as the straight distance between the most posteriorly projecting points of the heel (Pternion) to the most anteriorly projecting point (Acropodion) of the first or second toe whichever was bigger when the foot was fully stretched.

The collected data was entered in Microsoft Excel. Coding of the variables was done. SPSS for windows (Statistical package for social service version 17) was used for analysis. Interpretation of the collected data was done by using suitable statistical methods like regression analysis. Linear regression equations for stature estimation were calculated using the appropriate variables.

Observations and Results:

Data of 100 subjects was compiled and analysed. Gender wise 65% were male whereas remaining were female subjects. Variations observed in dimensions of foot length and heights in both the genders are as follows. In males, stature varied from 143.10 cm to 185.50 cm with mean values of 166.03 cm with a standard deviation of 7.88 cm. In females, it varied from 132.40 cm to 171.20 cm with mean values of 157.24 cm and standard deviation of 6.03 cm. (Table 1)

The linear regression equations were derived for estimation of statures from right foot length (FLRT) and left foot length (FLLT) in males and females. The correlation coefficients between stature and dimensions of foot were found to be positive and statistically significant. (Table 2)

Discussion:

At times fragments of soft tissues are found disposed off in the open, in ditches at the crime scene and the same are brought to forensic experts for the purpose of identification and such type of cases pose a real challenge especially in cases of mass disasters. Whenever a body is recovered in mutilated or fragmented state, the problem of identification of the person arises and this is a difficult task even for the most experienced forensic expert.

This study was devoted to the development of newer methods for personal identification from lower limb remains, by derivation of regression formulae for estimating stature from foot length. We devised the linear regression equations for

Table 1: Distribution of the Study Subjects according to Stature and Foot Dimensions

Sr. No.	Dimensions	Sex	Mean ± SD (Min.-Max.)
A	**Sex wise stature (in cm)**		
1	Height	Male	166.03 ± 7.88
			(143.10 - 185.50)
		Female	157.24 ± 6.03
			(132.40 - 171.20)
B	**Sex wise right foot length (in cm)**		
1	Foot length (Right)	Male	23.68 ±1.41
			(19.42 - 26.61)
		Female	20.07 ±1.43
			(17.10 -24.36)
C	**Sex wise left foot length (in cm)**		
1	Foot length (Left)	Male	22.05 ±1.48
			(21.74 - 26.92)
		Female	20.89 ±1.43
			(21.28 - 24.69)
D	**Sex wise right foot breadth (in cm)**		
1	Foot breadth (Right)	Male	8.4 ±0.57
			(7.74 - 10.55)
		Female	8.6 ±0.74
			(6.95 - 10.41)
E	**Sex wise left foot breadth (in cm)**		
1	Foot breadth (Left)	Male	8.1 ±0.67
			(7.24 - 11.03)
		Female	7.8 ±0.74
			(6.97 - 10.78)

Table 2: Regression Formula from Foot Dimensions for Both the Sexes

Parameters	Regression Equation of Males	r	Regression Equation of Females	r
FLRT	Height = 98.159 + 3.746 × FLRT	0.821	Height = 91.242 + 3.284 × FLRT	0.837
FLLT	Height = 97.843 + 3.651 × FLLT	0.787	Height = 90.976 + 3.041 × FLLT	0.876
FBRT	Height = 162.270 + 1.141 × FBRT	0.431	Height = 142.274 + 2.275 × FBRT	0.464
FBLT	Height = 163.942 + 0.987 × FBLT	0.394	Height = 141.861 + 2.571 × FBLT	0.473

FLRT- Foot Length Right, FLRT- Foot Length Left, FBRT- Foot Breadth Right, FBRT- Foot Breadth Left

estimation of stature from foot length in both the genders. There was bilateral variation in left and right foot dimensions, with left side preponderance. The linear regression equation derived from foot length for estimation of stature showed a statistically significant relationship in both the genders.

Grivas TB *et al* [3] observed the relationship between foot length and stature in a large sample of 5093 juveniles in, average age being 11.47±2.71 years. It was suggested that foot length can estimate the stature and weight of a juvenile, especially after adjusting for age and sex.

Another study established relationships between lower limb dimensions and stature on a sample of students residing in Delhi. They measured stature, trochanteric height, thigh length, lower leg length, leg length, and foot height, breadth, and length. They concluded that stature can be deduced using dimensions of the lower limb [4].

Sanli *et al* [5] analyzed the relationship between hand length, foot length and stature among 155 adults using multiple linear regression analyses. They found multiple linear regression model for both genders together to be the best model with the highest values for the coefficients of determination R^2 = 0.861 and R^2 adjusted = 0.859, and multiple correlation coefficient R = 0.928.

3000 English criminals were studied and regression formulae were derived for estimation of stature from foot length, 166.457 + 4.031 (foot-25.688) ± 2.9 cms. It was concluded that general multiple linear regression model was highly significant and validated with highest values for the coefficients of determination R^2=0.769 and multiple correlation coefficient r=0.877 [6].

Another study on North West Indian subjects also suggested that a true relationship existed only between foot length and stature, and the relationship in other combination of variables was affected to a great extent by foot length alone [7].

Others [8] also suggested that foot length displays a biological correlation with height and the latter can be estimated from foot length whereas Singh and Phookan [9] studied male population of Assam and suggested foot length to be a better indicator of stature than foot breadth. These studies support our view regarding use of foot length.

A study from Himachal Pradesh [10] observed the relationship between stature and dimensions of hands and feet on a group of 246 subjects 17 to 20 years old. In their study also the highest correlation coefficient existed between stature and foot length. The lowest standard error of estimate indicated that the foot length provides highest reliability and accuracy in estimating stature.

Our study involves stature estimation from foot measurements with foot in completely stretched position. Jasuja *et al* [11] reported stature estimation from stride length by measuring it while walking fast on smooth substrate and it was compared with the stride length in the normal pattern of walking. They found that for faster pace, formulae are different but the range of error for estimation of stature remained same.

A study among Gujjars of North Indian community examined the relationship between stature and foot dimensions among 200 subjects (100 males and 100 females). They devised linear and multiple regression equations for estimating stature using foot dimensions [12]. These results are cohort with findings of present study.

This study has several strengths. First, to our knowledge, very few similar studies are available in the literature. Second, all the interviews and examinations were conducted by single person, which provided uniformity in data gathering. On the other hand, inclusion of limited number of cases is an evident limitation of this study. The current study is only a pilot study and final conclusions could be only drawn after a full study

including adequate number of subjects of both sexes in the study.

Conclusion:

Derived linear regression equations estimate the stature reliably and accurately that would be of immense value in the field of personal identification. Stature and foot dimensions are positively correlated with each other. The regression equation derived in the study can be used reliably for estimation of stature in a diverse population group.

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